Remarks

Reconsideration of this application is requested. Claims 1, 5, 7, 9-12, 16, 18, and 21 have been amended. Claim 19 has been canceled. Claims 1-18, 20 and 21 remain pending in the application.

Objections to the Drawings

The Examiner has objected to the drawings, and in particular FIG. 4. The Examiner has stated that reference numeral "12" should be changed to "100" for consistency with the specification.

In response, the applicant is filing herewith a complete set of formal drawings which will take the place of the originally filed informal drawings. The applicant has included an amendment to FIG. 4 as requested by the Examiner in this set of formal drawings. It is believed that this amendment to FIG. 4 overcomes the Examiner's objection. It is additionally believed that the included formal drawings fulfill the requirement of providing the drawings in formal format.

Objections to the Specification

The Examiner has objected to the specification because of contained informalities. The applicant in response has amended pages 9, 11, 13 and 14 to correct these informalities. Replacement paragraphs are provided herewith

indicating the amendments made. It is believed the amendments to the specification overcome the Examiner's objections.

Objections to the Claims

The Examiner has objected to claims 5, 7, 9, 10, 12 and 16 for various informalities. The applicant in response, has amended claims 5, 7, 9, 10, 12 and 16 as suggested by the Examiner. It is believed that these amendments to the claims overcome the Examiner's objections.

Claim Rejections – 35 U.S.C. § 112

The Examiner has rejected claims 1-21 under 35 U.S.C. §112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

With respect to claim 1, the Examiner has stated that it is unclear as to the structural relationship between "an inlet channel" and the other elements of the apparatus, and likewise the "outlet channel". In response, the applicant has amended claim 1 to clarify the inclusion of an inlet channel for introducing liquid fuel into the fuel processor and an outlet channel for transporting hydrogen enriched gas out of the fuel processor. It is believed that these amendments clarify the structural relationship between the inlet and outlet channels and the other elements of the apparatus.

With respect to claim 3, the Examiner has states that it is unclear as to the structural relationship between "an integrated heat source" and the other elements of the apparatus. In response the applicant has amended claim 3 to state that the integrated heat source is thermally coupled to the reaction zone and vaporization zone using thermally conductive channels or thermally conductive vias. It is believed that this amendment clarifies the structural relationship between the integrated heat source and the other elements of the apparatus.

With respect to claim 4, the Examiner asserts that "the integrated heat source" lacks proper positive antecedent basis. In response, the applicant has amended claim 4 to show dependency on claim 3, where "the integrated heater" is introduced.

With respect to claims 7 and 15, the Examiner states that it is unclear as to the structural relationship between the "thermally conductive structures" and the other elements of the apparatus. The applicant in response has amended claims 7 and 15 and asserts that as claimed in claim 3, from which claim 7 depends, an integrated heat source is thermally coupled to the reaction zone and vaporization zone using thermally conductive channels or thermally conductive vias. Claim 7 depends therefrom and further defines that the integrated heat source couples heat to the reaction zone using thermally conductive channels. Likewise, claim 11 states that an integrated heater is thermally coupled to the reaction zone and the vaporization zone using thermally conductive channels or thermally conductive vias.

Claim 15, depending therefrom states that the integrated heater couples heat to the reaction zone using thermally conductive channels. The applicant asserts that the structural relationship is defined through use of the terms thermally coupled which implies in this instance a structure relationship that would provide for the passage therethrough of heat from the heat source to the reaction zone.

With respect to claims 13 and 15, "the integrated heater" lacks proper positive antecedent basis. In response, the applicant has amended claim 13 to show dependency on claim 12, where "the integrated heater" is introduced. Claim 15 depends from claim 13.

With respect to claims 14 and 21, the Examiner asserts that the applicant must first define "the integrated heater" as a "chemical heater" before reciting further structural limitations for the chemical heater. In response, the applicant has amended claims 14 and 21 to claim a hydrogen generator "wherein the integrated heater is a chemical heater.....". It is believed that these amendments adequately define the "integrated heater" as being a "chemical heater".

With respect to claim 19, the Examiner asserts that it is unclear as to the relationship between an "an integrated heater" (line 2) and the "an integrated heater" set forth in claim 18, line 8. Furthermore, the Examiner asserts that it is unclear as to the structural relationship between the "thermally conductive channels" (line 3) and the other elements of the apparatus. In response, the applicants respectfully

request the cancellation of claim 19. It is believed the cancellation of this claim renders moot the Examiner's objection.

Claim Rejections – 35 U.S.C. § 102

The Examiner has rejected claims 1-3, 5-8, 10-16 and 18-21 under 35 U.S.C. 102(b) as being anticipated by Hsu et al., U.S. Patent No. 5, 858,314, hereinafter referred to as Hsu. The Examiner in making this rejection enumerates specific rejections as to each claim. The applicant in response respectfully disagrees with the rejections in light of the amendments to the claims and remarks made herein.

The applicant asserts that Hsu discloses a reactor built using discrete pieces of ceramic plates, with catalyst deposited on them and having thermally conducting plates interleaved between these ceramic plates, and gas manifolds to feed reactants and to get output gases. The entire assembly is sealed in a gas tight enclosure to make the reformer unit.

The applicants assert that Hsu discloses a very cumbersome method of making the reformer unit. It is claimed to be a compact unit. However, the applicant asserts that arranging discrete pieces of the reforming plates and thermally conducting plates and sealing in a gas tight enclosure as described takes up lot of room and it is not really suited for portable power applications, where the target application for the reformer is to supply hydrogen gas for fuel cell power source running cell phone, PDA, 2-way radio or a laptop computer.

The applicant in contrast has disclosed and amended the claims to claim a small, compact, highly integrated reformer processed using the multilayer ceramic technology into a single monolithic three- dimensional unit. The applicant has described a device in which the various components are arranged to achieve fuel reforming in a small compact unit with high efficiency for portable power applications. This requires careful arrangement of the components that are thermally integrated, fewer or no external tube connections between the various components of the reformer for allowing the passage of reactants and product gas flows, gas tight sealed packaging to prevent leakage of explosive (H2) and toxic (CO) gases to the external environment and prevent the outside atmosphere leakage into the reactor to change the reaction equilibrium or degrade the catalyst.

The monolithic ceramic unit disclosed and claimed by the applicant accomplishes these requirements in a small compact unit for portable power application. The applicant's device is fabricated using multilayer ceramic technology. The required features of the various components (vaporizer, reformer, combustor etc. in the fuel reformer unit) required for the final unit are processed separately on individual ceramic sheets in green state (unsintered) and then they are laminated maintaining the structural integrity and sintered to form a monolithic ceramic unit. Communication between the various components is achieved by forming the required channels in the green state. This way it is possible to achieve simple and gas tight connections between the components, such that the only external required connections would be fuel inlet connected to the fuel tank and gas

out put connected to the fuel cell. Since, in the three dimensional arrangement the vaporizer, reformer and the combustor can be arranged close to each other usually separated by a single layer of ceramic (10-250 um thick), good thermal integration between them is possible by careful location of these components in the reformer unit without any added thermal conductive layers. Inherent design of the reformer and the processing method accomplishes this task without any added complexity. For example, due to the size (35x15x5mm) of the applicant's reformer sufficient hydrogen (from methanol/water input) suitable for a 1W size fuel cell is able to be produced, with only the fuel input and gas out connections. The device is ideally suited for portable power application. Compact design minimizes the total surface area (requiring minimum insulation around the reactor) and minimizes the losses into the surrounding through the reactor, thereby maximizing the fuel efficiency for portable power applications.

Accordingly, the applicant asserts that there is no anticipation in the device of Hsu to disclose a monolithic multilayered three dimensional hydrogen generator as claimed by the applicants in independent claims 1, 11, and 18. In that claims 2, 3, 5-8, 10, 12-16, 20, and 21 from independent claims 1, 11, and 18, respectively, the applicant asserts that they must contain each and every element of the claim from which they depend, and are therefore also in a condition for allowance. Claim 19 has been canceled herein. In light of the above remarks, the Applicant believes the 35 U.S.C. 102 rejection in light of the teaching of Hsu has been overcome. Notice to that effect is requested.

Next, the Examiner has rejected claims 1-4 and 10-13 under 35 U.S.C. 102(b) as being anticipated by Ahmed et al., U.S. Patent No. 5,942,346 hereinafter referred to as Ahmed. The Examiner in making this rejection enumerates specific rejections as to each claim. The applicant in response respectfully disagrees with the rejections in light of the amendments to the claims and remarks made herein.

The applicant asserts that Ahmed discloses a hydrogen generator, and more particularly, an autothermal reformer, which is different from the applicant's reformer. In the autothermal reformer of Ahmed, part of the fuel in the reformer is oxidized by supplying a controlled amount of oxygen (or air). The heat generated by the oxidation reaction is balanced with endothermic steam reforming reaction. The hydrogen output from this processor is less about 35-50% compared to 75% in the steam reforming reactor described by the applicant. In addition, CO content in the output gas from the reactor described by Ahmed et al. is high 5-10%, compared to 1-2% in our reactor. Higher CO content requires the addition of a preferential oxidation reactor for CO clean up. Ahmed et al. describes a reactor in a metal tube; the initial portion of which consists of a discrete ceramic monolith unit (similar to the monolith used in automotive catalytic converters). Again as described earlier with respect to the device of Hsu, assembling these discrete units into a small compact unit for portable power application is very complicated and not feasible as described in the application.

The applicant in contrast discloses and claims a fuel reformer that is formed as a monolithic unit, and having a catalyst powder packed into the reformer cavity or

whereby the catalyst is coated inside the ceramic walls of the reactor. In the applicant's device, the entire assembly is made using multilayer ceramics and thus there is no need to add additional discrete catalyst coated ceramic monoliths as described by Ahmed et al.

Accordingly, the applicant asserts that there is no anticipation in the device of Ahmed to disclose a monolithic multilayered three dimensional hydrogen generator as claimed by the applicants in independent claims 1 and 11. In that claims 3-4, 10, 12, and 13 depend from independent claims 1 and 11, respectively, the applicant asserts that they must contain each and every element of the claim from which they depend, and are therefore also in a condition for allowance. In light of the above remarks, the Applicant believes the 35 U.S.C. 102 rejection in light of the teaching of Ahmed has been overcome. Notice to that effect is requested.

Claim Rejections - 35 U.S.C. § 103(a)

The Examiner has rejected claims 4, 9, and 17 under 35 U.S.C. 103(a) as being unpatentable over Hsu, as applied to claims 1 and 11 above, and further in view of Ghosh et al., U.S. Patent No. 5,961,932, hereinafter referred to as Ghosh. The Examiner in making this rejection enumerates specific rejections as to each claim.

The applicant respectfully disagrees with this rejection and asserts that the claims are not obvious in light of the teaching of Hsu, in view of Ghosh. The applicant disagrees with the Examiner's assertions regarding the obviousness and asserts that Hsu in view of Ghosh fails to disclose the monolithic three-dimensional device as previously described with respect to Hsu. The applicant asserts Ghosh et al. describes a monolithic ceramic reactor processed using multilayer ceramic technology. It is a simple reactor with microfluidic connections for reactants mixing, filtering and reactions, and does not describe the essential features required for the generation of hydrogen from hydrocarbon fuels such as methanol. Since the purpose of the reformer is to produce hydrogen gas for fuel cell power source, a very careful design of the ceramic reactor is required for the fuel reformer with good efficiency. A combustor is required to provide heat for the steam reforming reaction. It needs to be placed close to the reforming reaction chamber for efficient heat transfer. The fuel vaporizer can be placed on the outer portions to capture the waste heat from the combustor exhaust gases. The applicants therefore assert that further modification of Hsu with the teaching of Ghosh also fails to disclose the applicant's claimed device. More specifically, the applicant asserts that further modification of Hsu by adding a resistive heater or serpentine channels fails to make obvious the applicant's device.

In that claims 4, 9, and 17 depend from independent claims 1 and 11, the applicant asserts that they must contain each and every element of the claim from which they depend, and are therefore also in a condition for allowance. In light of the above remarks, the Applicant believes the 35 U.S.C. 103 rejection in light of the

teaching of Hsu, in view of Ghosh has been overcome. Notice to that effect is requested.

Finally, the Examiner has rejected claims 1-3 and 5-21 under 35 U.S.C. 103(a) as being unpatentable over Autenrieth (DE 197 46 251) in view of Ghosh. The Examiner in making this rejection enumerates specific rejections as to each claim.

The applicant respectfully disagrees with this rejection and asserts that the claims are not obvious in light of the teaching of Hsu, in view of Ghosh. The applicant respectfully disagrees with this rejection and asserts that the claims are not obvious in light of the teaching of Autenrieth, in view of Ghosh. The applicant disagrees with the Examiner's assertions regarding the obviousness and asserts that Autenrieth in view of Ghosh fails to disclose the monolithic three-dimensional device as previously. The applicant asserts that Autenrieth discloses a device that is somewhat similar to the applicant's device in the planar arrangement of reformer, combustor, vaporizer and exhaust gas flows for maximum heat transfer efficiency. However, accomplishing all the reformer tasks in a planar structure requires more surface area and the heat lost component to the surroundings increases as a function of the surface area. A combination of planar arrangement of some of the components and the three-dimensional approach for some of the as disclosed by the applicant is more efficient. Autenrieth et al. fails to disclose how they are stacking these plates in a gas tight enclosure, since this process inevitably involves expensive sealing methods and consumes more volume. The applicant's

monolithic ceramic structure approach simplifies this design for maximum efficiency for portable power applications. Autenrieth et al. also includes a CO preferential oxidation process to generate heat as well as clean up of CO in the output stream; however based on the applicant's experience and the literature, this is a very difficult process to control and an exactly specified amount of oxygen (or air) needs to the supplied and a very selective catalyst needs to be used to prevent hydrogen oxidation in that process, which needs to be kept maximum for the fuel cell use. In the applicant's device, the applicant provides for controlling of the steam reforming process to keep the CO content below 1-2% and does not use CO cleanup . The applicant asserts that further modification of the device of Autenrieth with the teaching of Ghosh (as previously described) also fails to make obvious the applicant's device.

Accordingly, the applicant asserts that the applicant's device is not obvious in light of the teaching of Autenrieth in view of Ghosh. The applicants have disclosed an entirely different monolithic multilayered three dimensional hydrogen generator as claimed in independent claims 1, 11, and 18. In that claims 2, 3, 5-10, 12-17, 20 and 21 depend from independent claims 1, 11, and 18, respectively, the applicant asserts that they must contain each and every element of the claim from which they depend, and are therefore also in a condition for allowance. Claim 19 has been canceled herein. In light of the above remarks, the Applicant believes the 35 U.S.C. 103 rejection in light of the teaching of Autenrieth in view of Ghosh has been overcome. Notice to that effect is requested.

No election to pursue a particular line of argument was made herein at the expense of precluding or otherwise impeding Applicants from raising alternative lines of argument later during prosecution. Applicants' failure to affirmatively raise specific arguments is not intended to be construed as an admission to any particular point raised by the Examiner.

The Applicant believes that the subject application, is in condition for allowance. Such action is earnestly solicited by the Applicant. In the event that the Examiner deems the present application non-allowable, it is requested that the Examiner telephone the Applicant's attorney or agent at the number indicated below so that the prosecution of the present case may be advanced by the clarification of any continuing rejection.

SUMMARY: Reconsideration is respectfully requested. In view of the foregoing amendments and remarks it is believed that the application, including claims 1-21, is now in condition for allowance. Notice to that effect is respectfully requested.

Authorization is hereby given to charge any fees necessitated by actions taken herein, including any extension of time fees, to Deposit Account 502117.

Respectfully submitted,

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